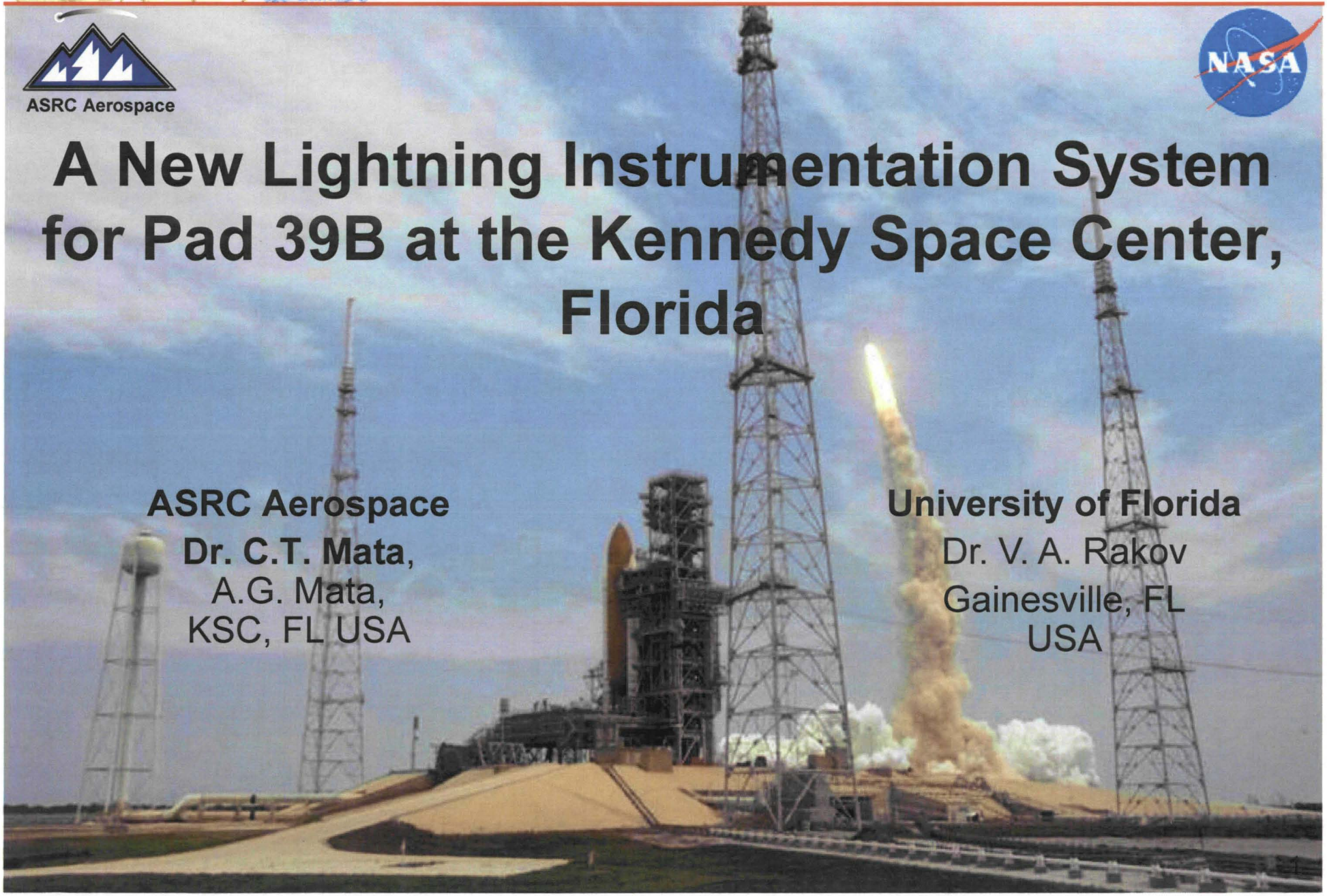
AMERICAN METEOROLOGICAL SOCIETY

ASRC Aerospace

NASA

A New Lightning Instrumentation System for Pad 39B at the Kennedy Space Center, Florida



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Gainesville, FL
USA

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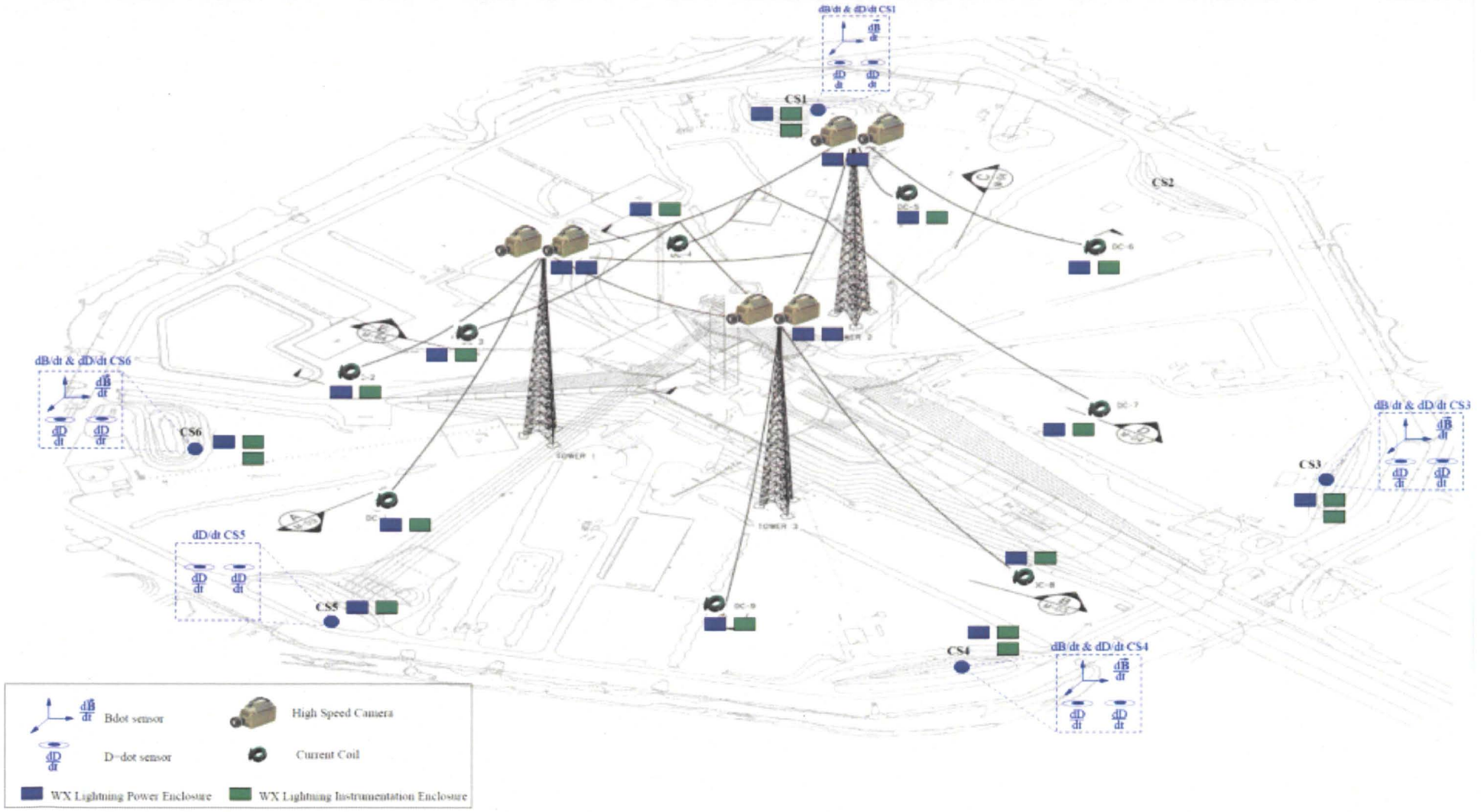
Lightning Instrumentation Architecture



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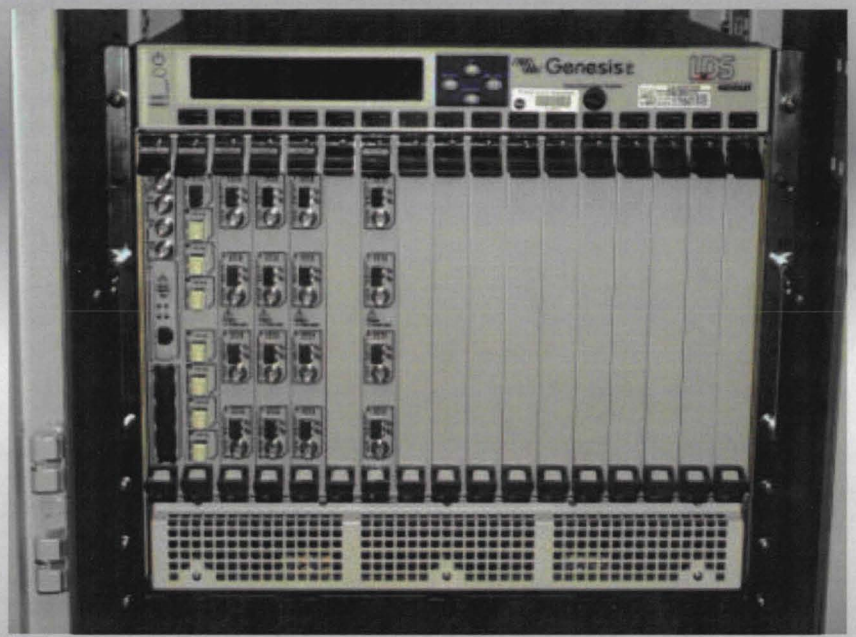
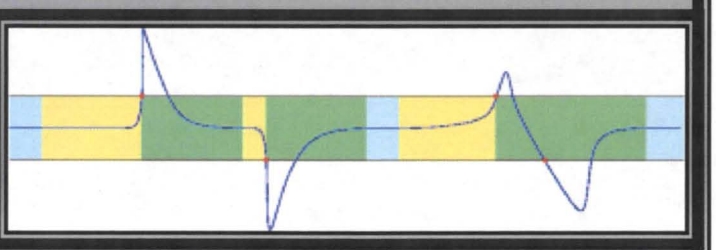
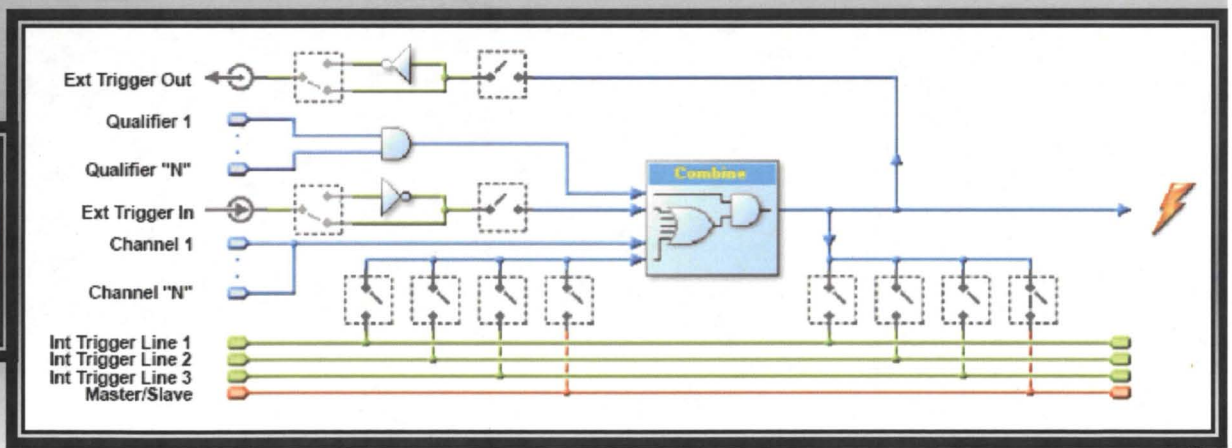
Instrumentation

Genesis Transient Recorder, HBM (Nicolet)



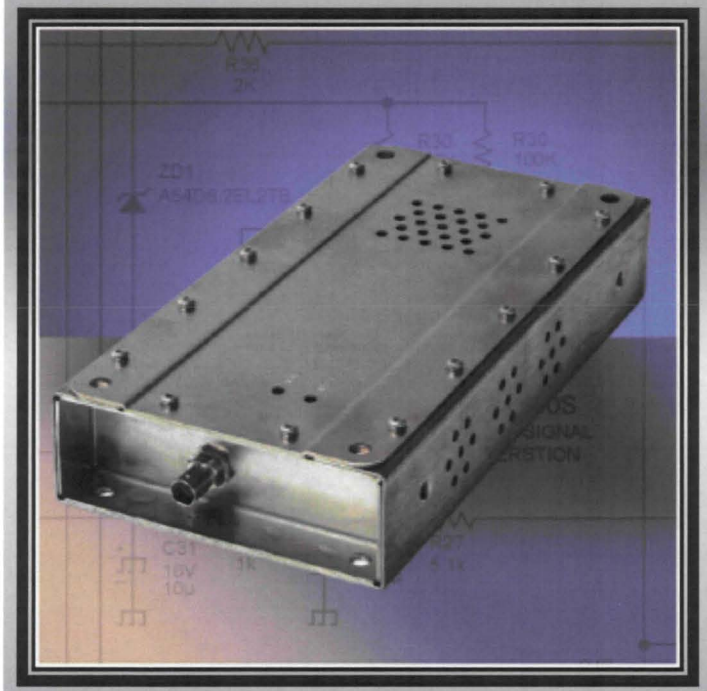
- Segmented Memory,
- FIFO, computer data transfer,
- No dead-time between segments (sweeps),
- 100 Megasamples/sec,
- Single mode fiber interface with time propagation delay compensation,
- Stretch trigger option,
- Comprehensive triggering capabilities,
- Master/Slave (shared trigger bus),
- Automated waveform exports,
- 60 channels/chassis x 8 chassis, 10 ns



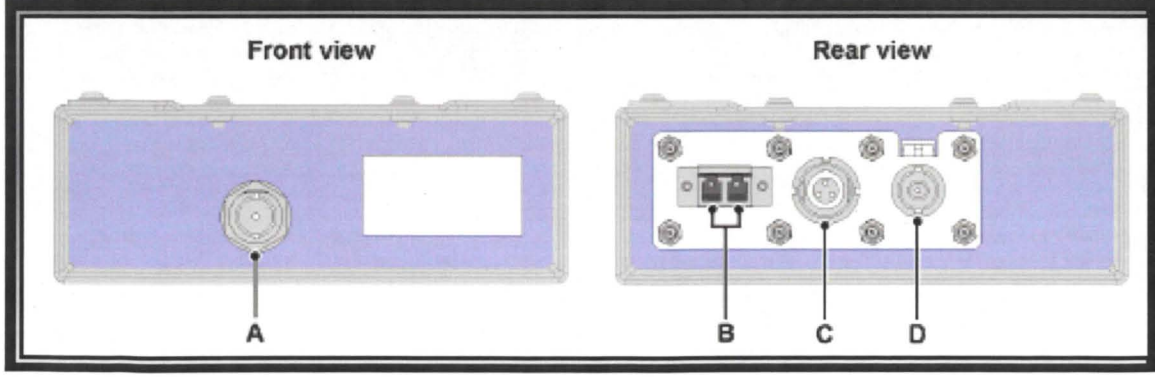


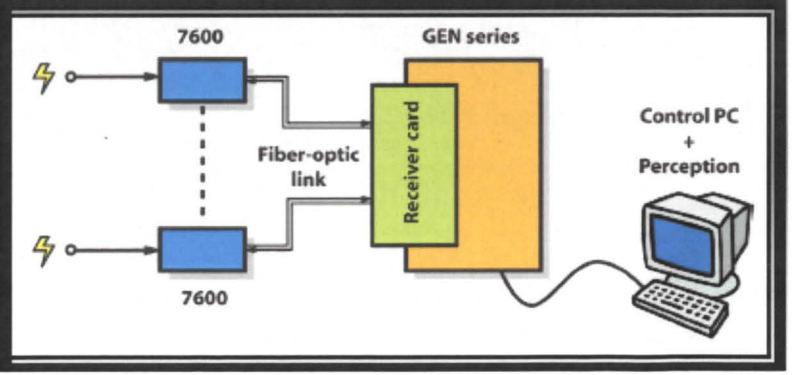
Instrumentation

Digitizer 7600, HBM (Nicolet)



- 12 VDC ± 5% 550 mA maximum
- 100 MS/sec, 25 MHz @ -3 dB, sync sampling
- Coupling AC/DC/GND/Reference
- ± 20 mV to ± 100 V Full Scale in 1, 2, 5 steps, 14 bits
- Vibration and shock test
- Temperature range: -10 ºC to +70 ºC
- Max Error: 1% DC to 5 MHz throughout Temp range
- Prototyped and tested at the ICLRT during the 2009 and 2010 campaigns
- **(A)** single-ended to isolated common input; **(B)** LC Duplex, 1310 nm, 4 km typ, 12 km max; **(C)** Power input; and **(D)** control output.





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Instrumentation

High Speed Cameras, Vision Research v310

- Two cameras per tower, level E,
- 1280x800 @ 3,200 fps, 8 GB, Color, HD-SDI Video Output to a HD recorder,
- Segmented memory, (20 segments, 80 ms)
- 50% post-trigger,
- Continuous recording,
- Restart after recording, FIFO,
- Triggered by the Genesis Transient Recorder, IRIG-B Synch
- 20-36 VDC, 70 W, Battery Bank
- Weatherproof enclosures with redundant AC units, and
- Stand alone temperature, humidity, power controller

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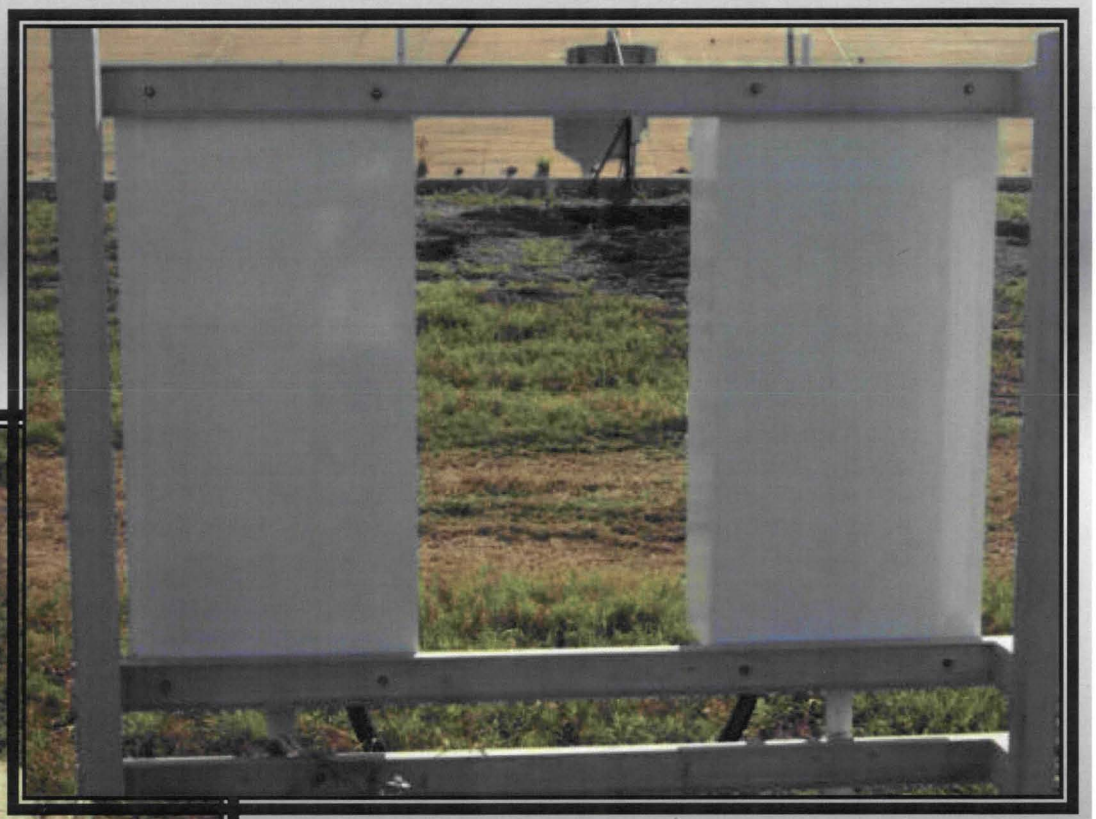
Downconductors

- Pearson Electronics 1330
- Usable rise-time: 250 ns
- 0.9 Hz to 1.5 MHz
- Maximum peak current 100 kA
- Current time product 65 A-s
- 23 MHz anti-aliasing filters



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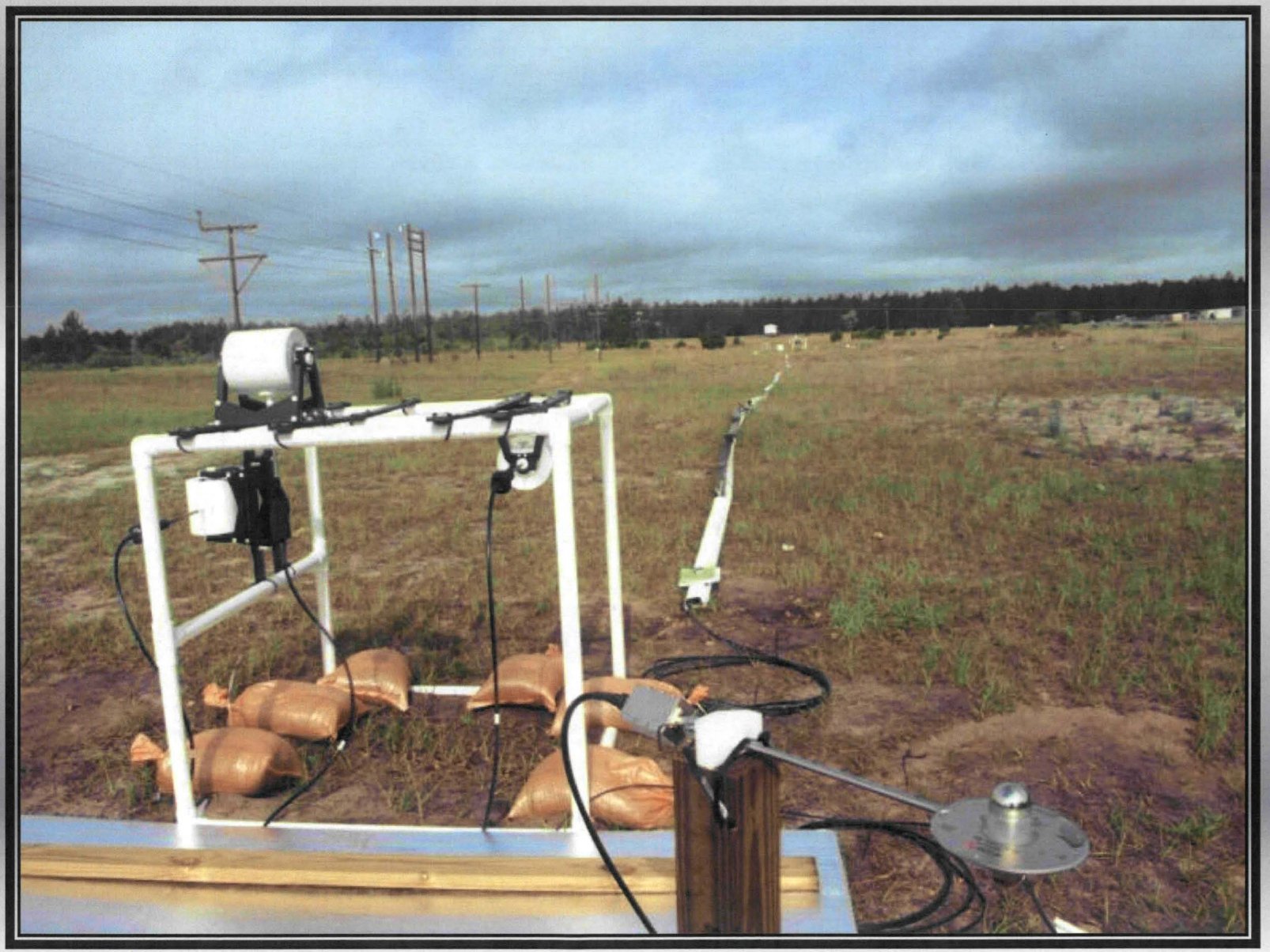
EM Field Stations, Camp Blanding



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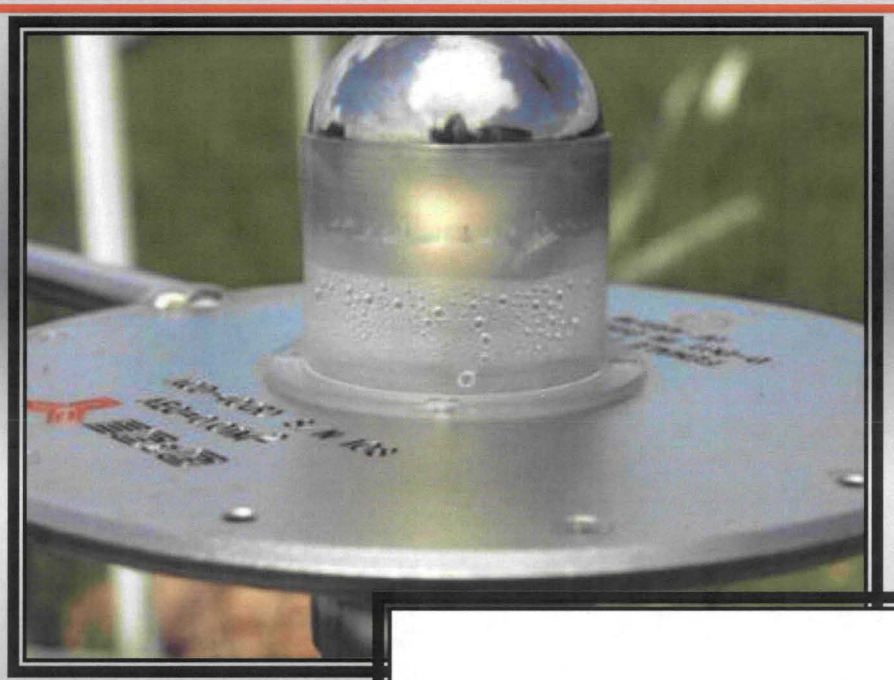
EM Field Stations, Camp Blanding



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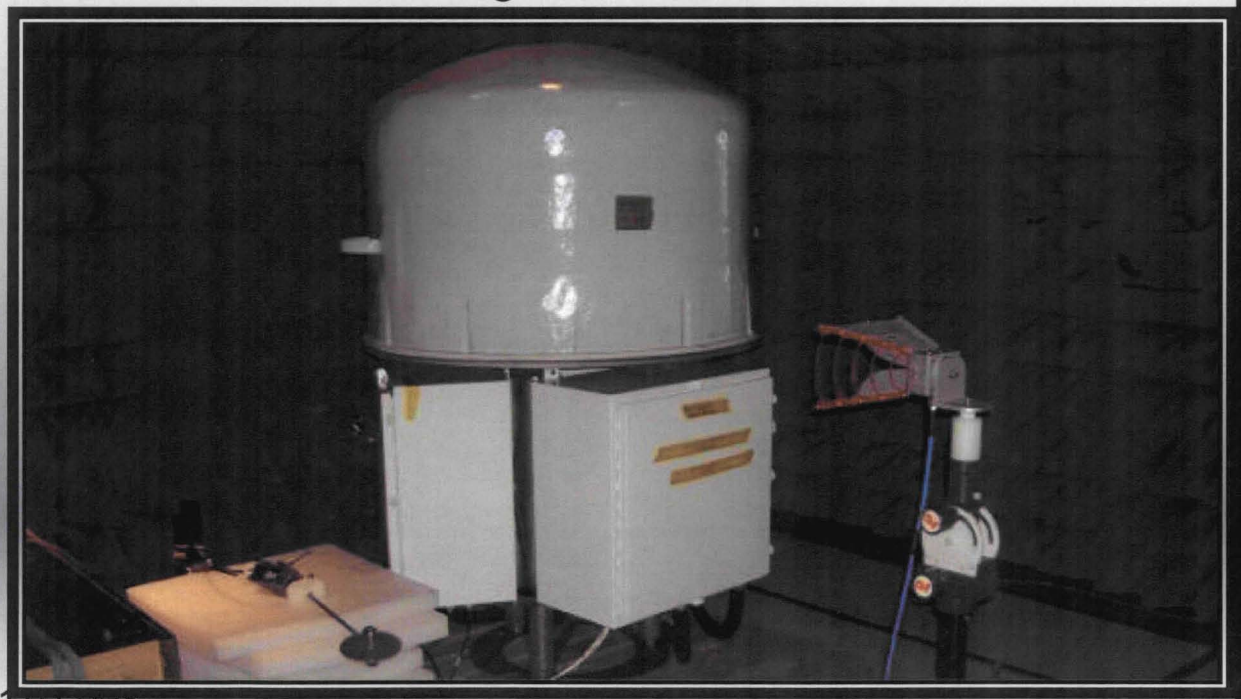
EM Field Stations

Four Stations with 3 Axis Bdot Sensors Each

- EG&G MGL-2 Bdot free field sensors,
- 100 Ω, differential twinaxial output, ≈ 300 MHz @ -3dB
- Balun to convert 100 Ω differential to 50 Ω, single mode,
- 23 MHz anti-aliasing filters,
- $A_{eq} = 1x10^{-2}$ m^2 ($V_{out} = A_{eq}$ x dB/dt),
- Max field change of $2x10^5$ Tesla/sec,
- Protected in a fiberglass dome,



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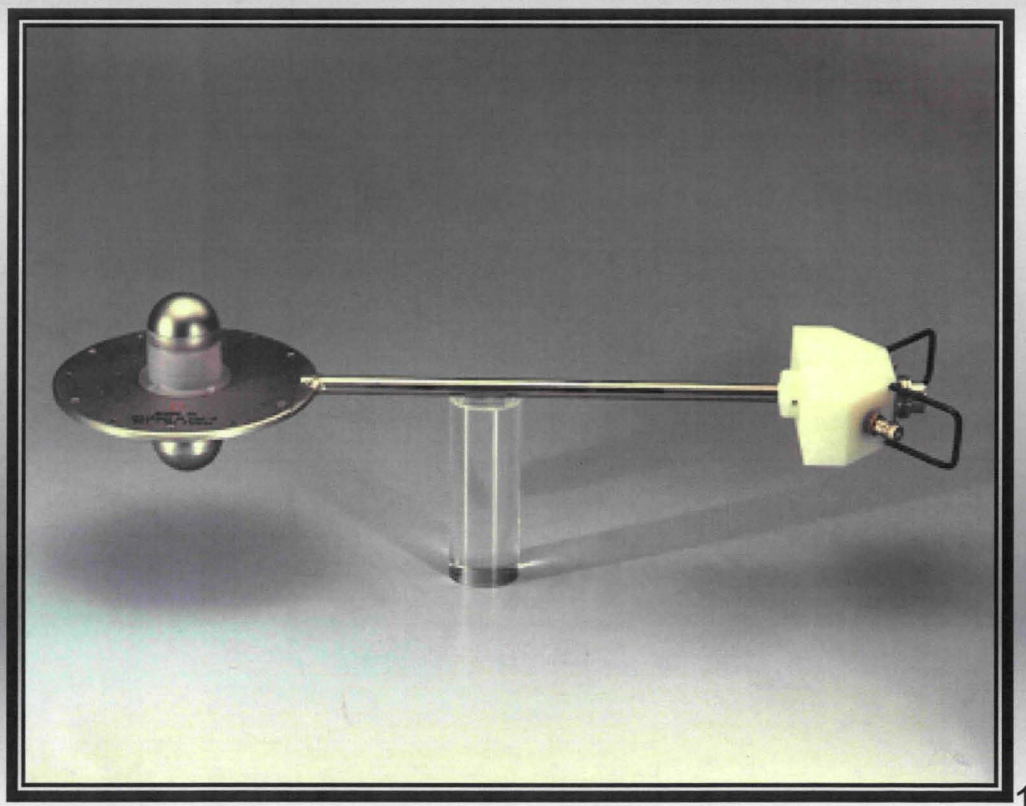
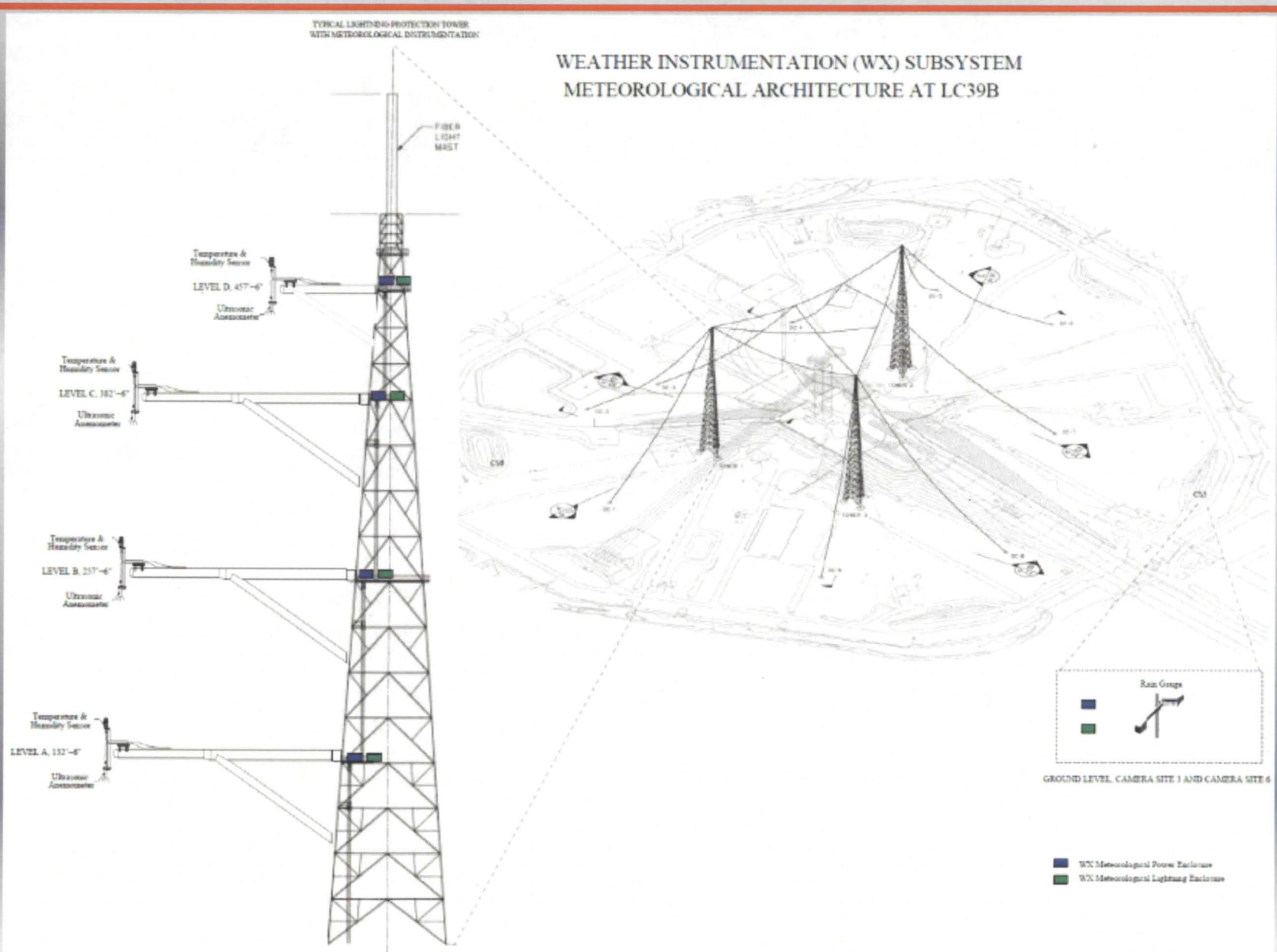
EM Field Stations

Five Stations with 2 Ddot Sensors Each

- EG&G? Prodyne?
- 100 Ω, differential twinaxial output, ≈ 1 GHz @ -3dB
- Balun to convert 100 Ω differential to 50 Ω single mode,
- 23 MHz anti-aliasing filters,
- $A_{eq} = 1x10^{-2}$ m^2 ($V_{out} = R \times A_{eq} \times dD/dt$),



Meteorological Instrumentation



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Lessons Learned

- EMI susceptibility must be performed,
- Be aware of specifications, datasheets,
- Test with the correct setup, configuration settings, and equipment interconnection,
- For a reliable 24/7 lightning instrumentation system, you have to test for extended periods of time,
- Work closely with the vendors,
- What are the IT concerns?
- We are still learning…

Data Acquired at Camp Blanding

1. Direct Triggered Lightning Strike to the scaled-down LPS (T3), at Camp Blanding, Florida
2. Nearby Triggered Lightning Strike (140 meters*) to the scaled-down LPS, at Camp Blanding, Florida

* 140 meters is the distance between the ICLRT Launch Tower and the dE/dt measurement underneath the scaled-down LPS

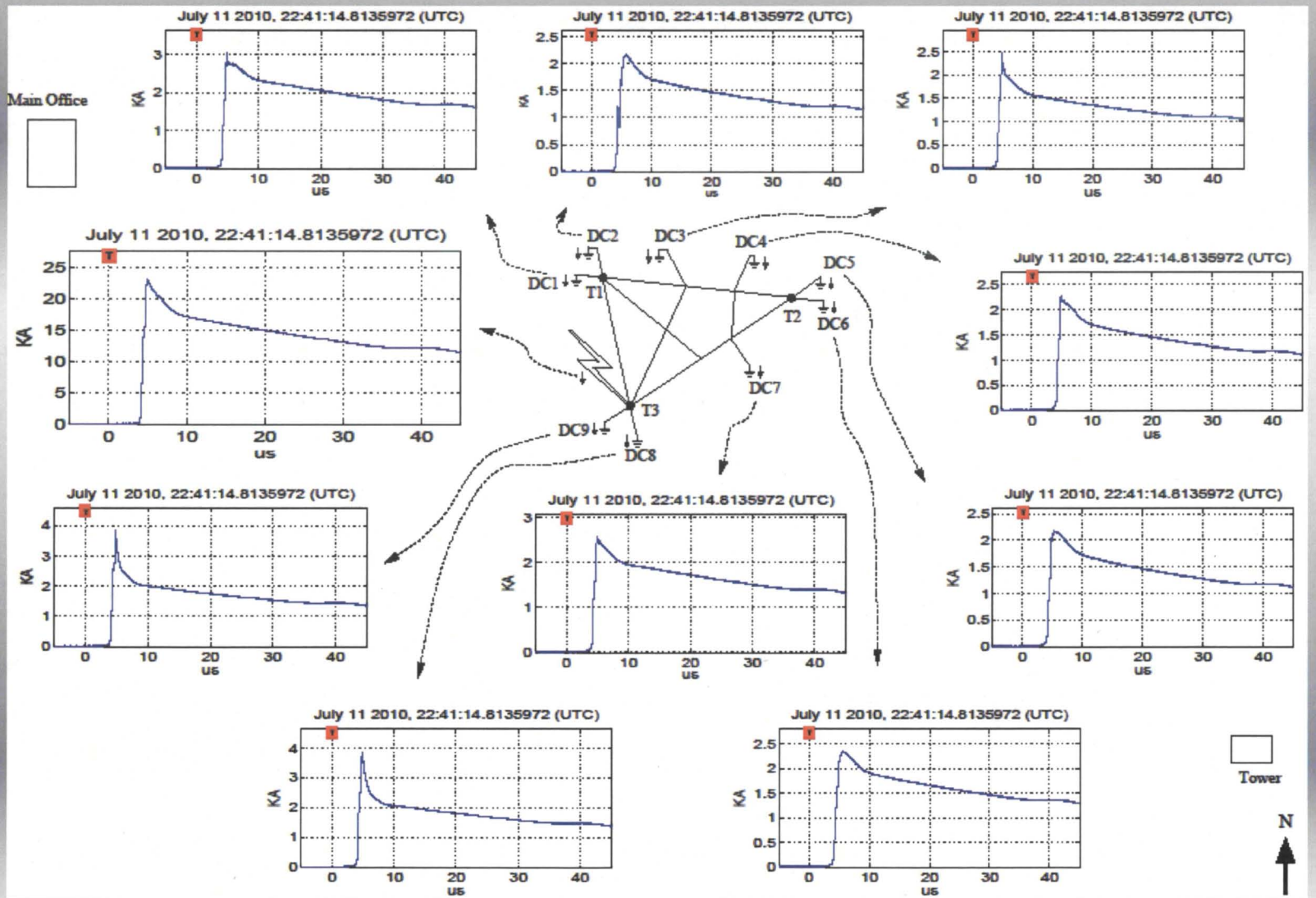
Waveforms presented include:

- Lightning current (LPS's T3 or ICLRT Launch Tower)
- 9 Down conductor currents [50us]
- 8 dE/dt [10us]
- 6 dH/dt [10us]
- Comparison of incident current and sum of all down conductors' current (Direct Triggered Lightning Strike)
- Comparison of selected dE/dt waveforms and sum of all down conductor's current (Nearby Triggered Lightning Strike)

Data Acquired at Camp Blanding

ASRC Aerospace

Down Conductor currents due to a direct triggered lightning strike to the LPS (T3)



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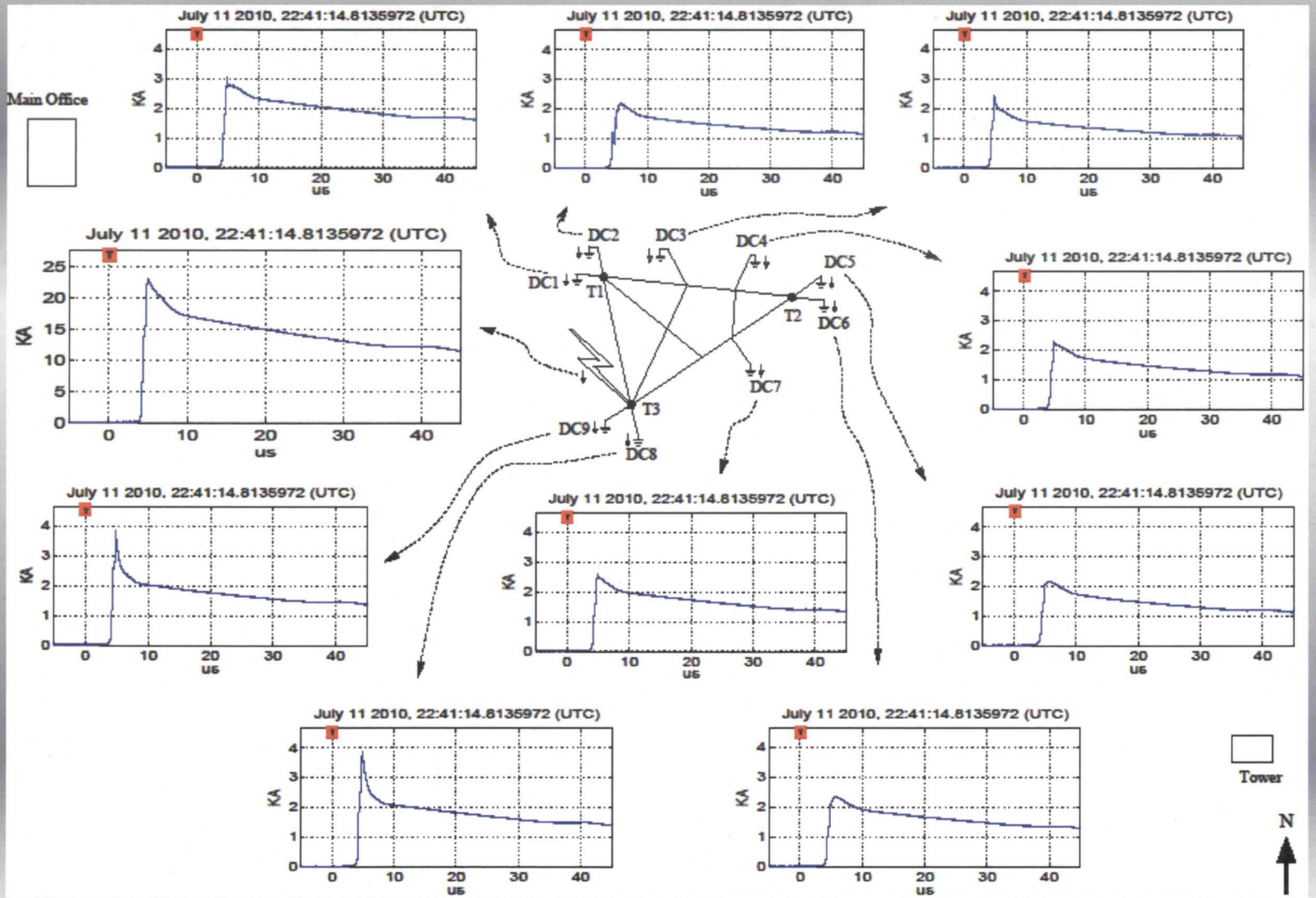
Down Conductor currents due to a direct triggered lightning strike to the LPS (T3)



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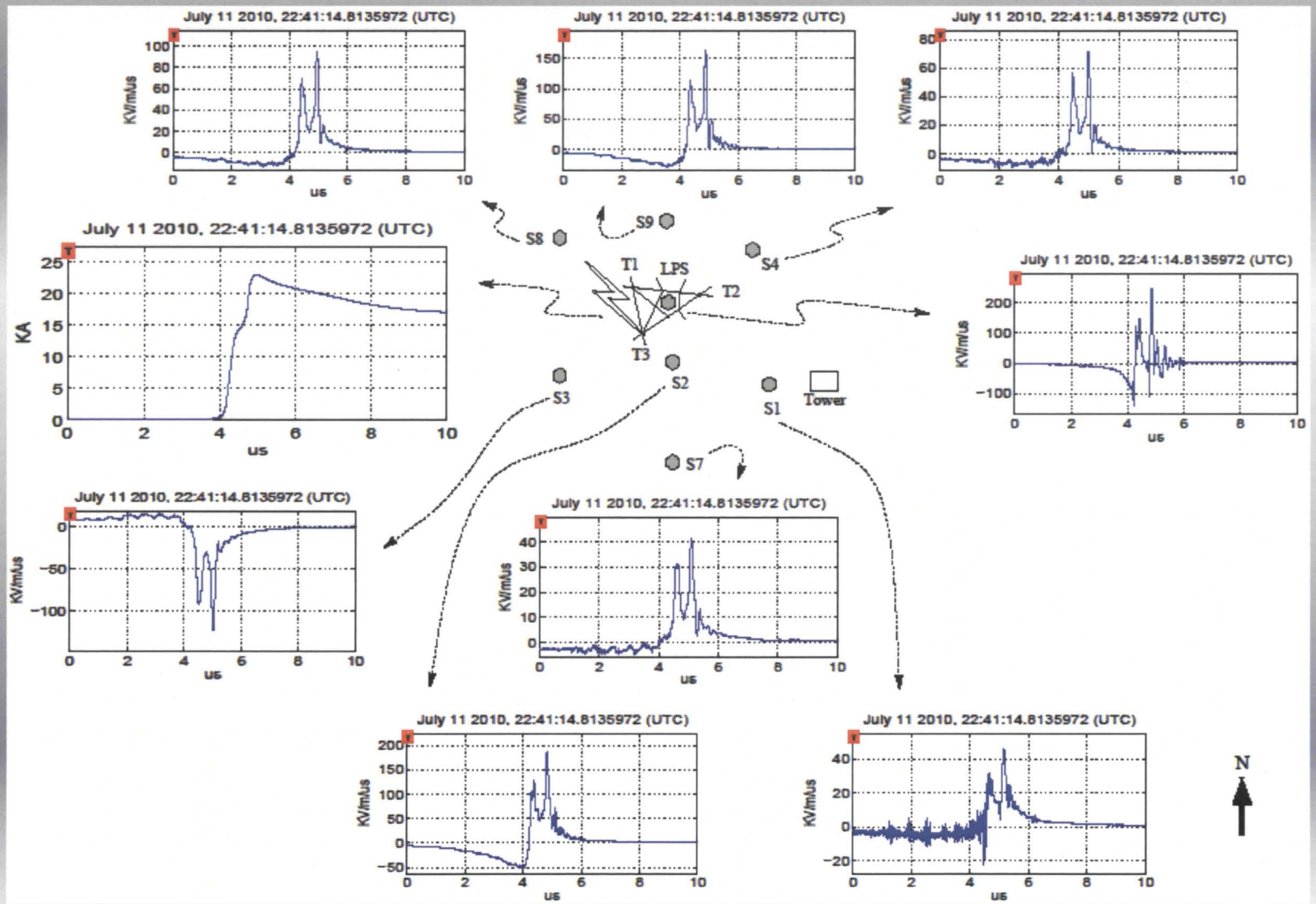
ASRC Aerospace

dE/dt due to a direct triggered lightning strike to the LPS (T3)



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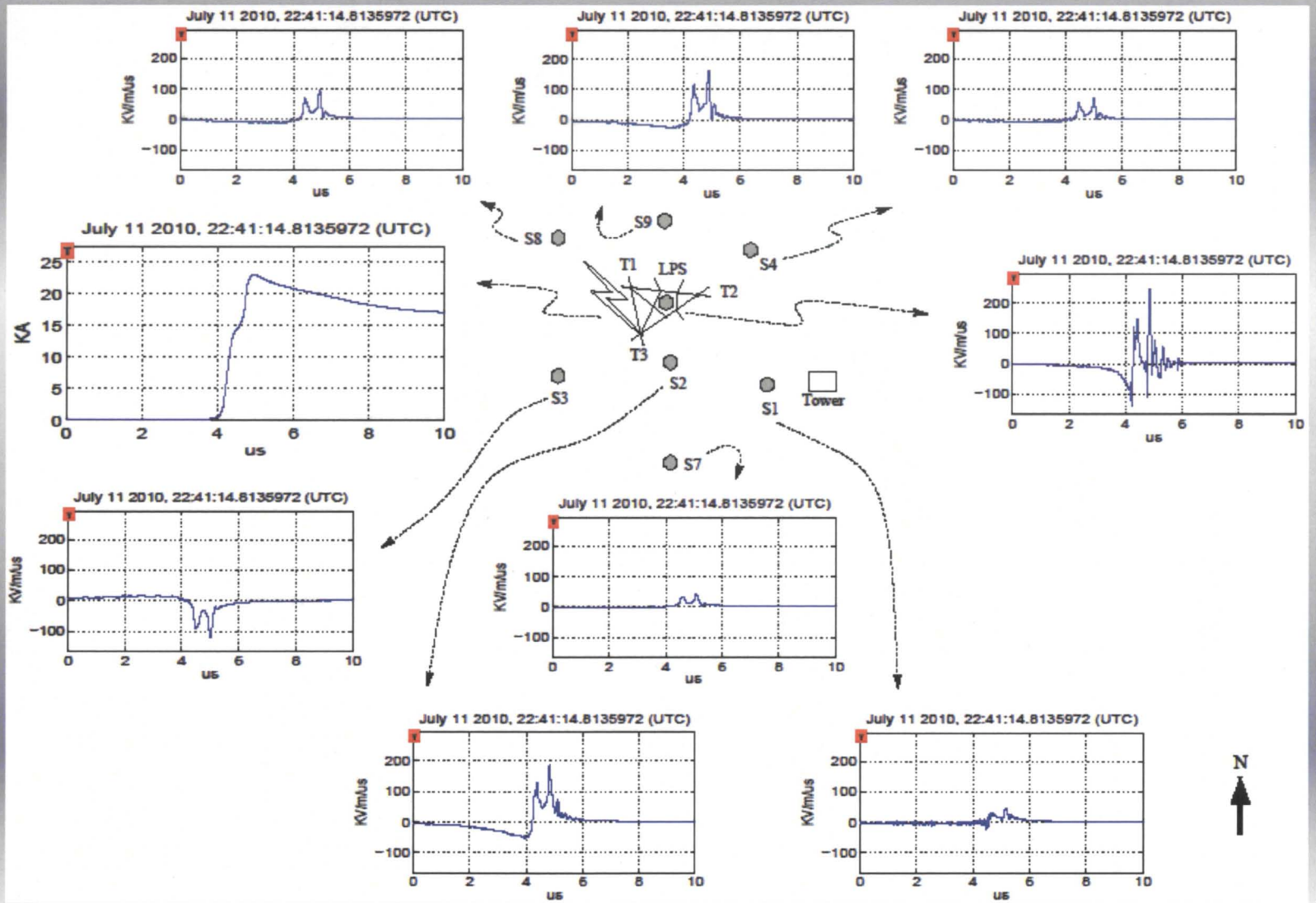

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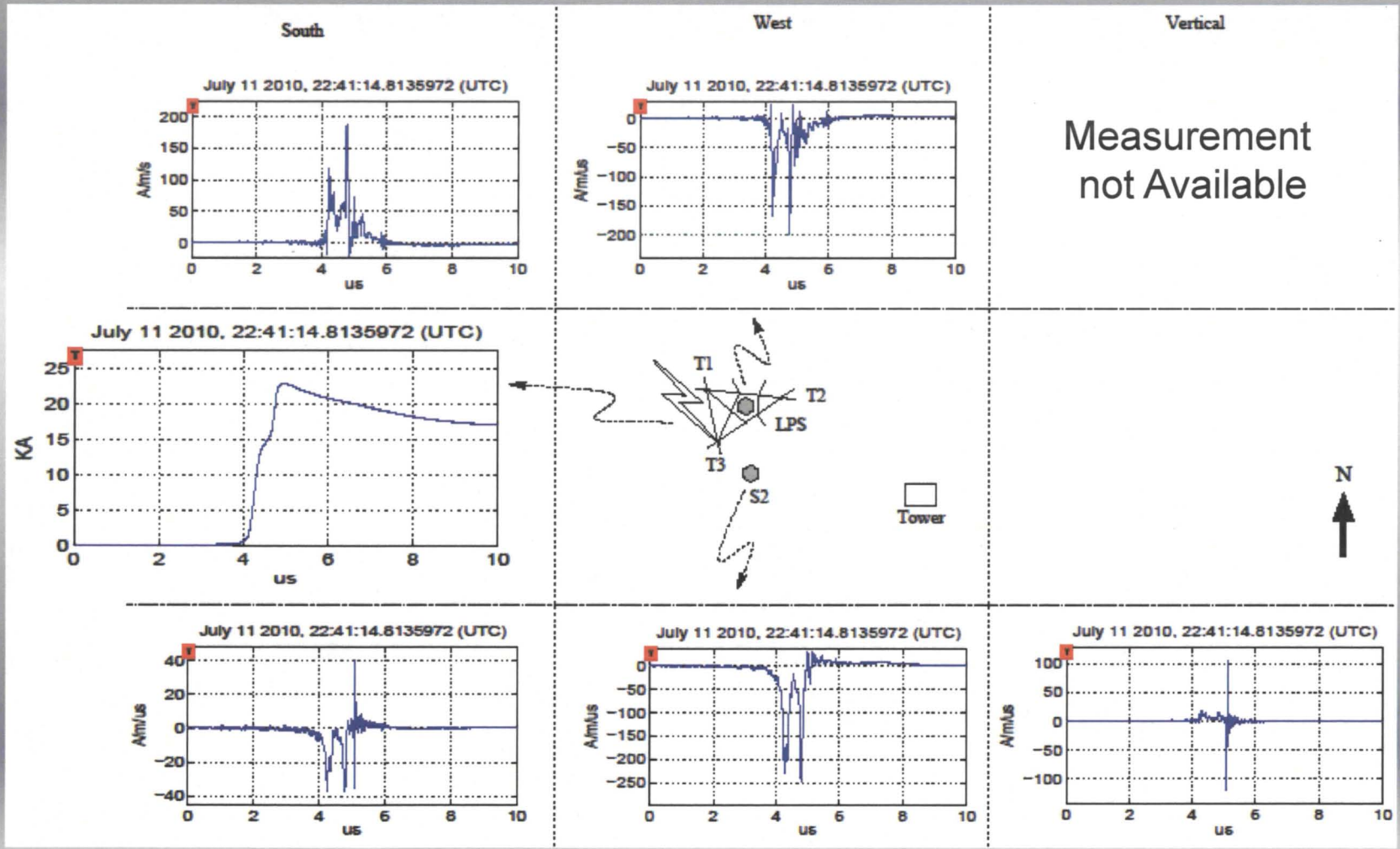
dH/dt due to a direct triggered lightning strike to the LPS (T3)



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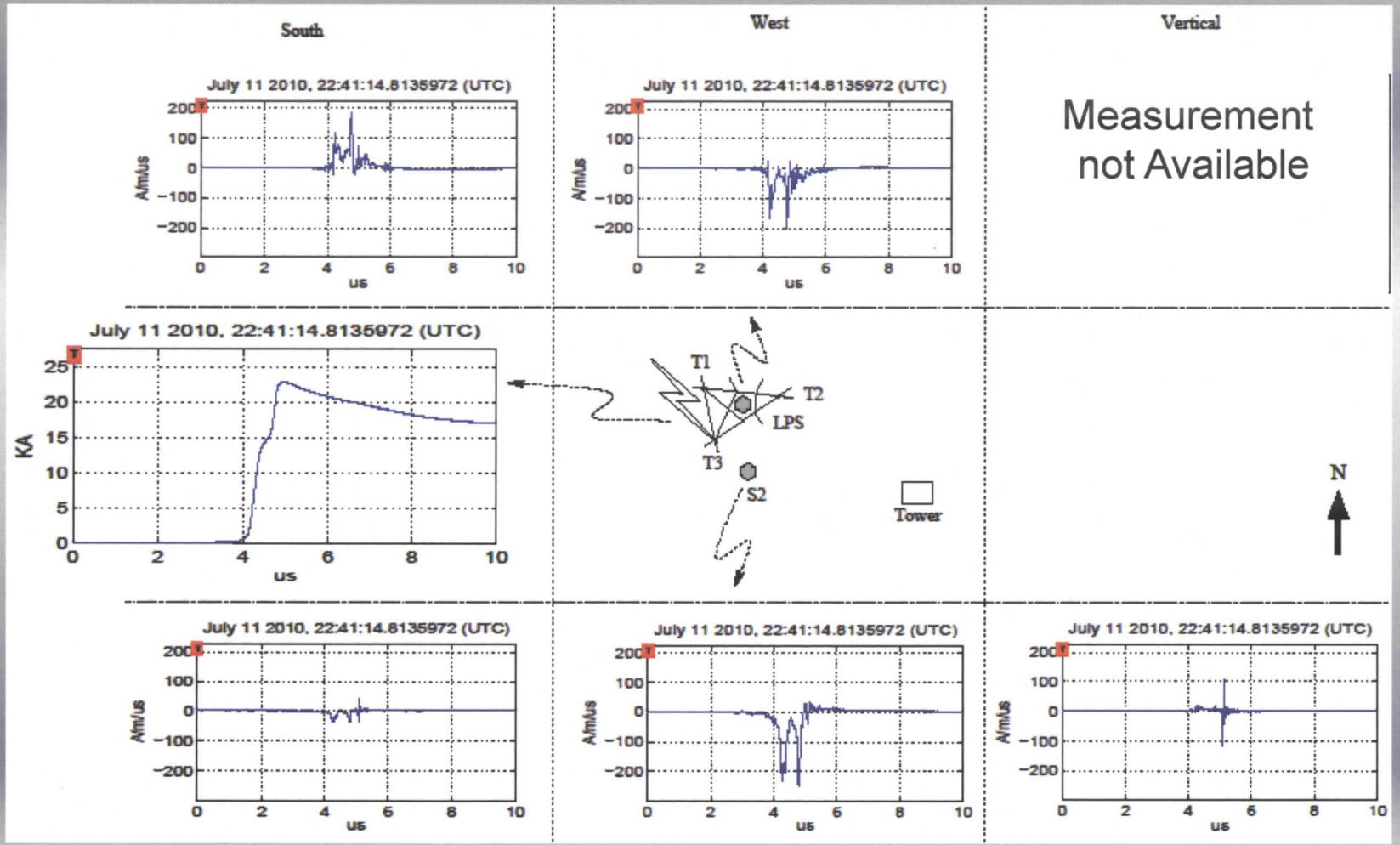
dH/dt due to a direct triggered lightning strike to the LPS (T3)



Data Acquired at Camp Blanding

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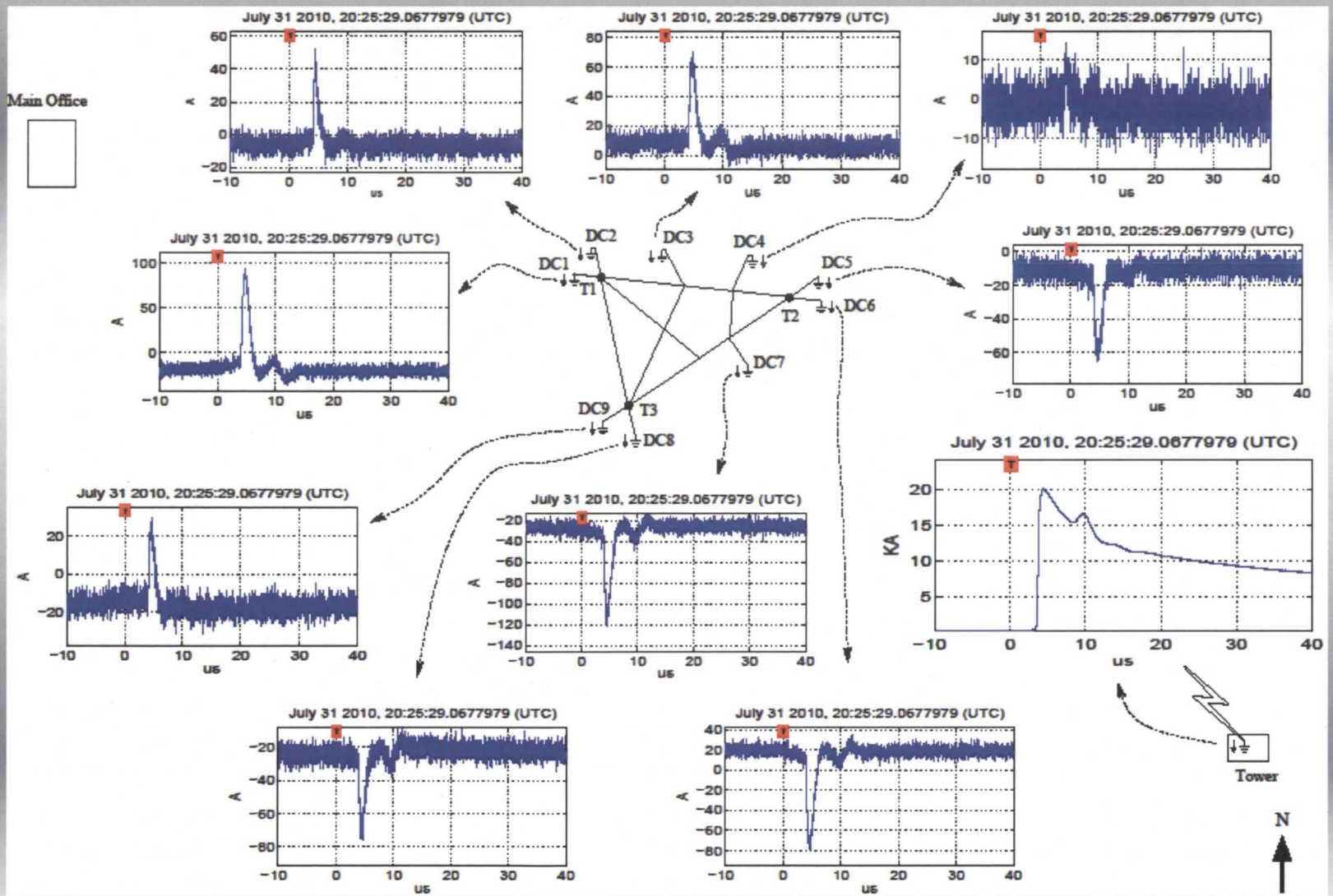
Down Conductor currents due to a nearby triggered lightning strike (Tower Launcher)



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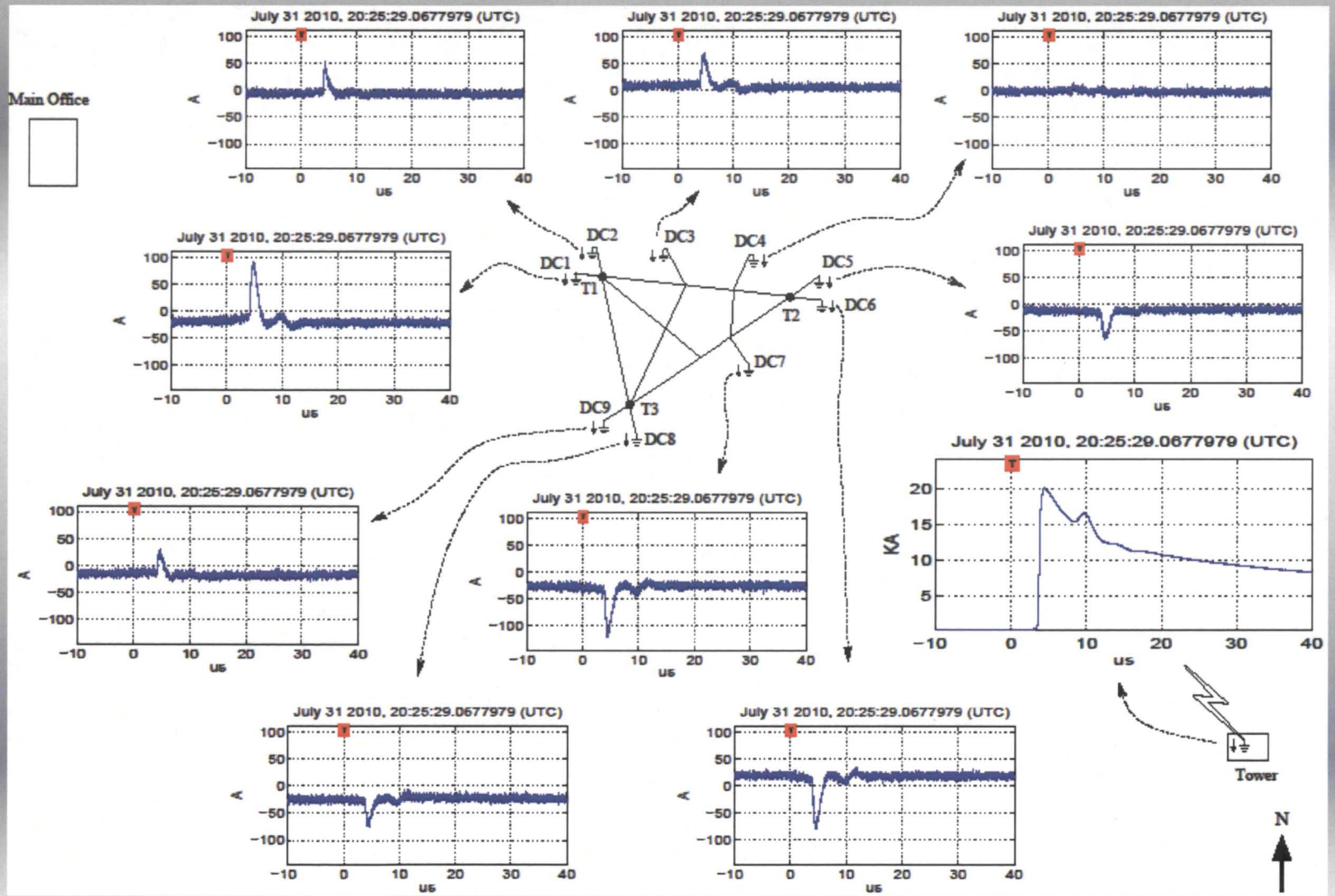

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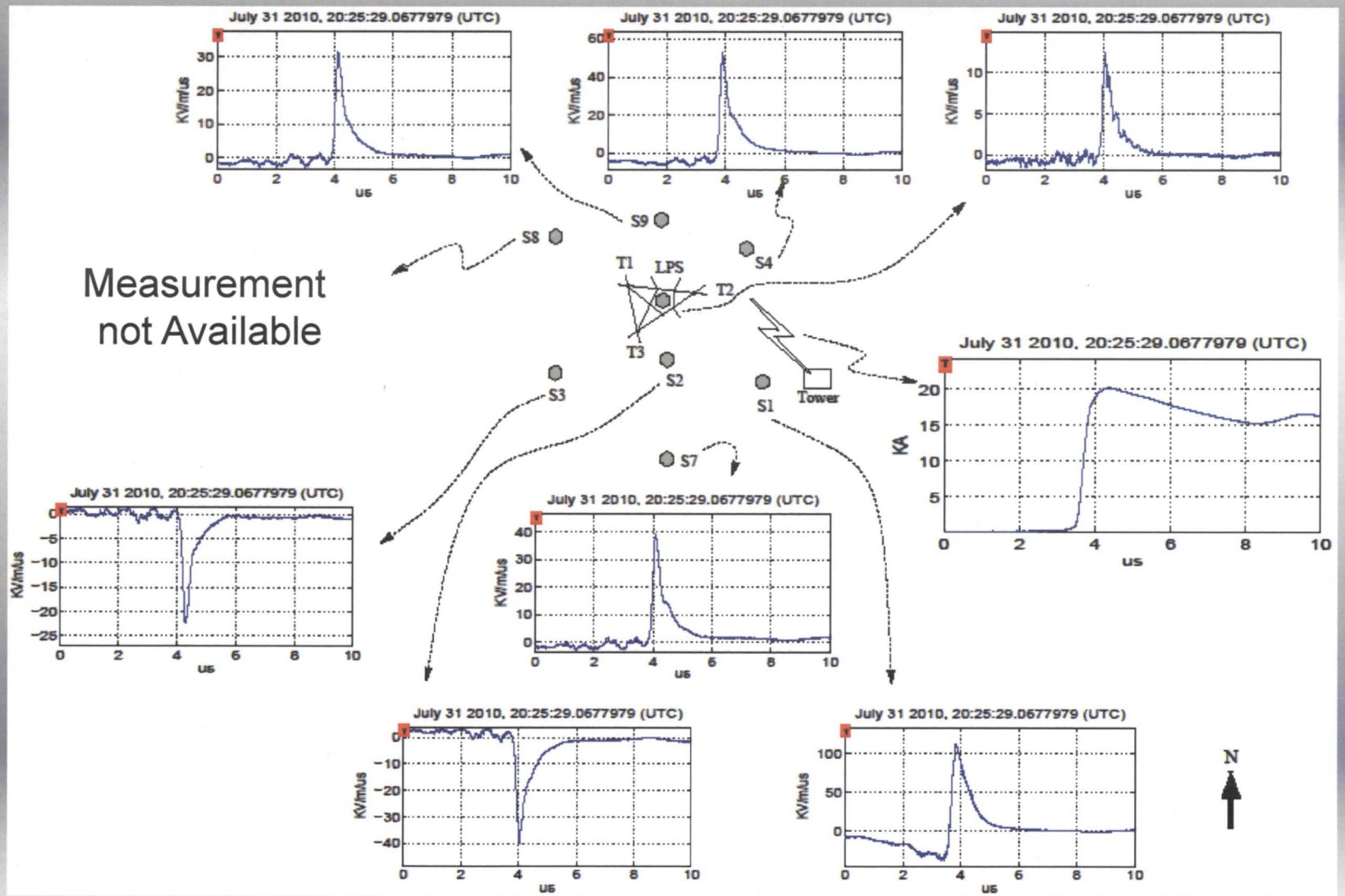
dE/dt due to a nearby triggered lightning strike (Tower Launcher)



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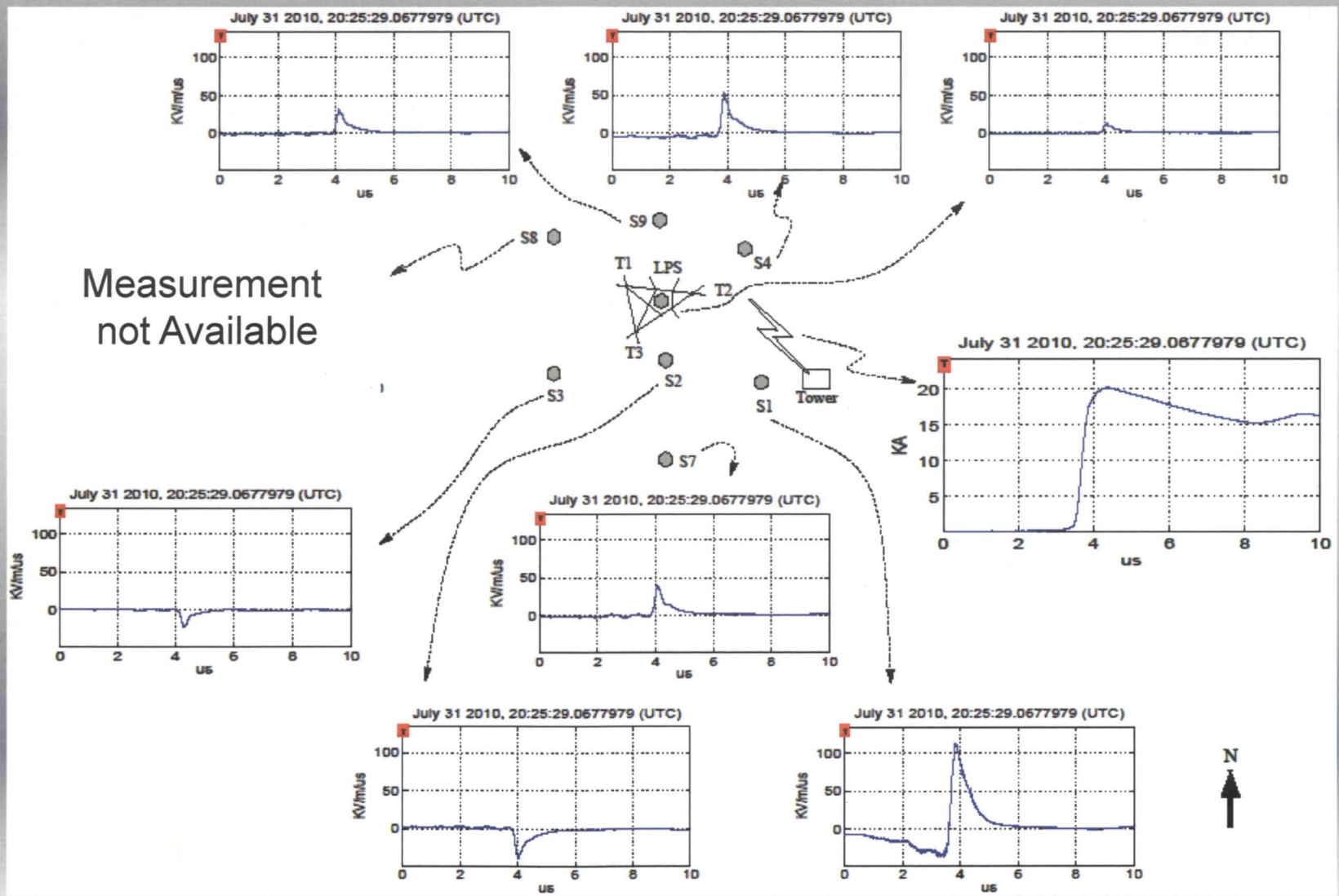
dE/dt due to a nearby triggered lightning strike (Tower Launcher)



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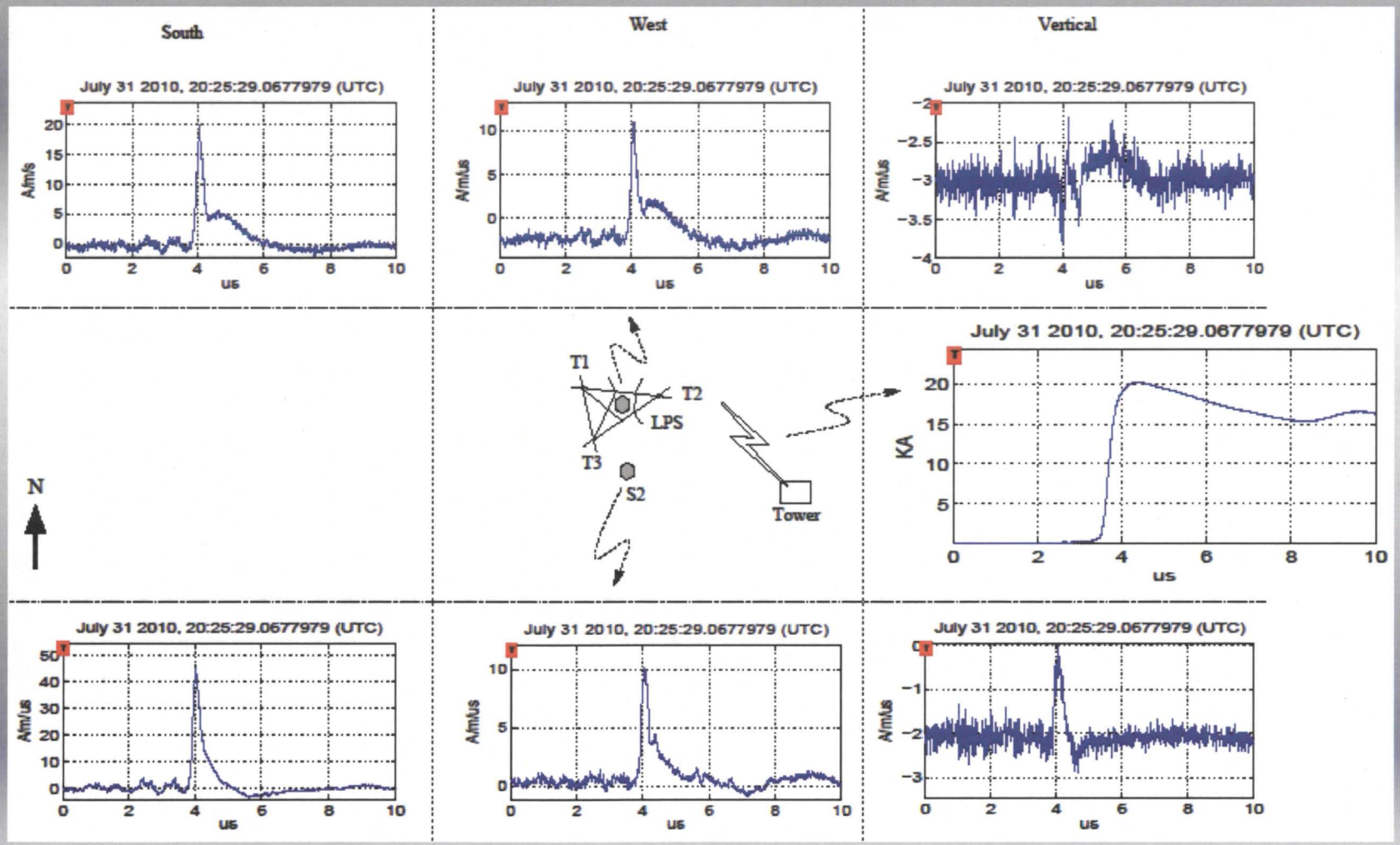
dH/dt due to a nearby triggered lightning strike (Tower Launcher)



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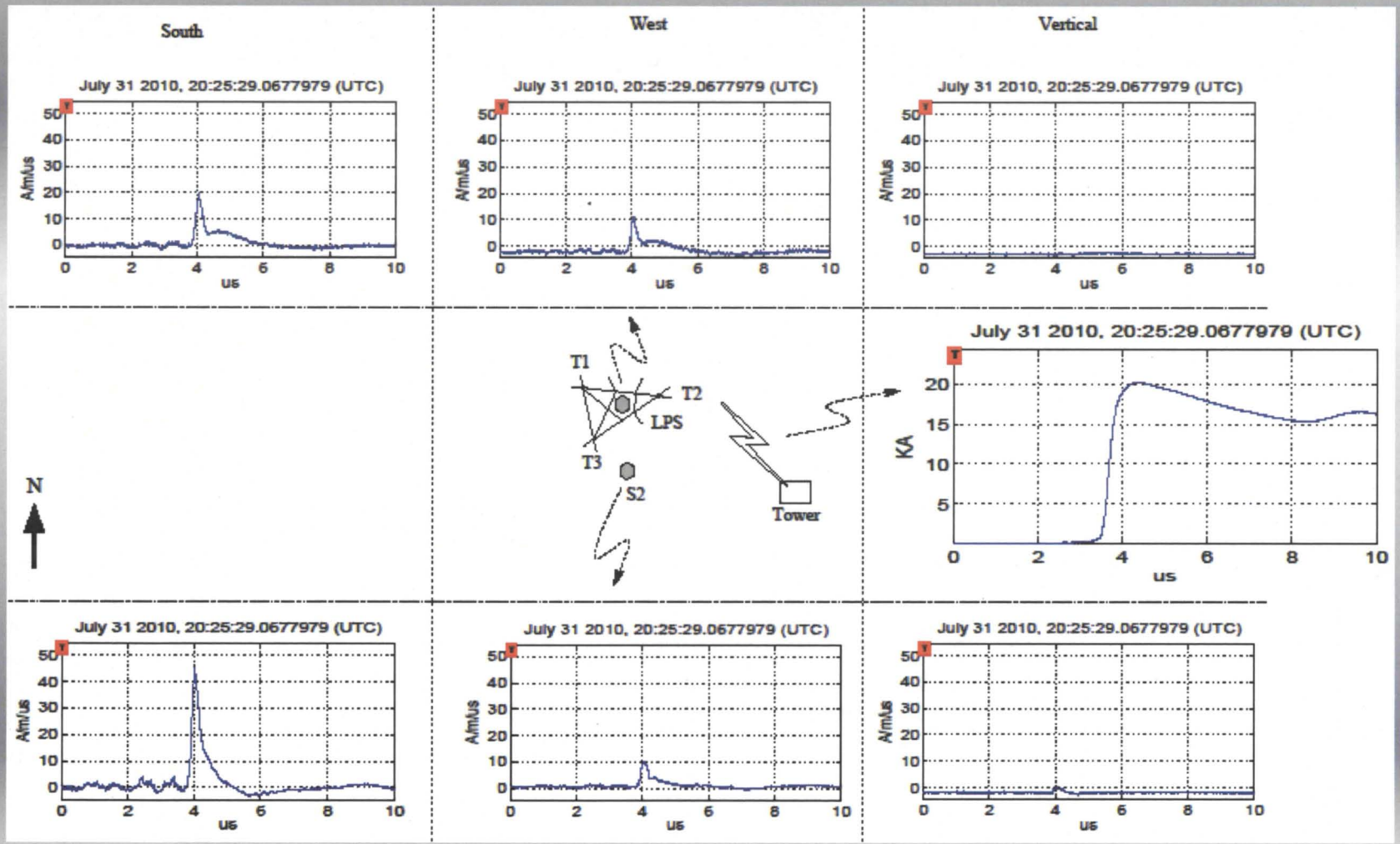
dH/dt due to a nearby triggered lightning strike (Tower Launcher)



Data Acquired at Camp Blanding

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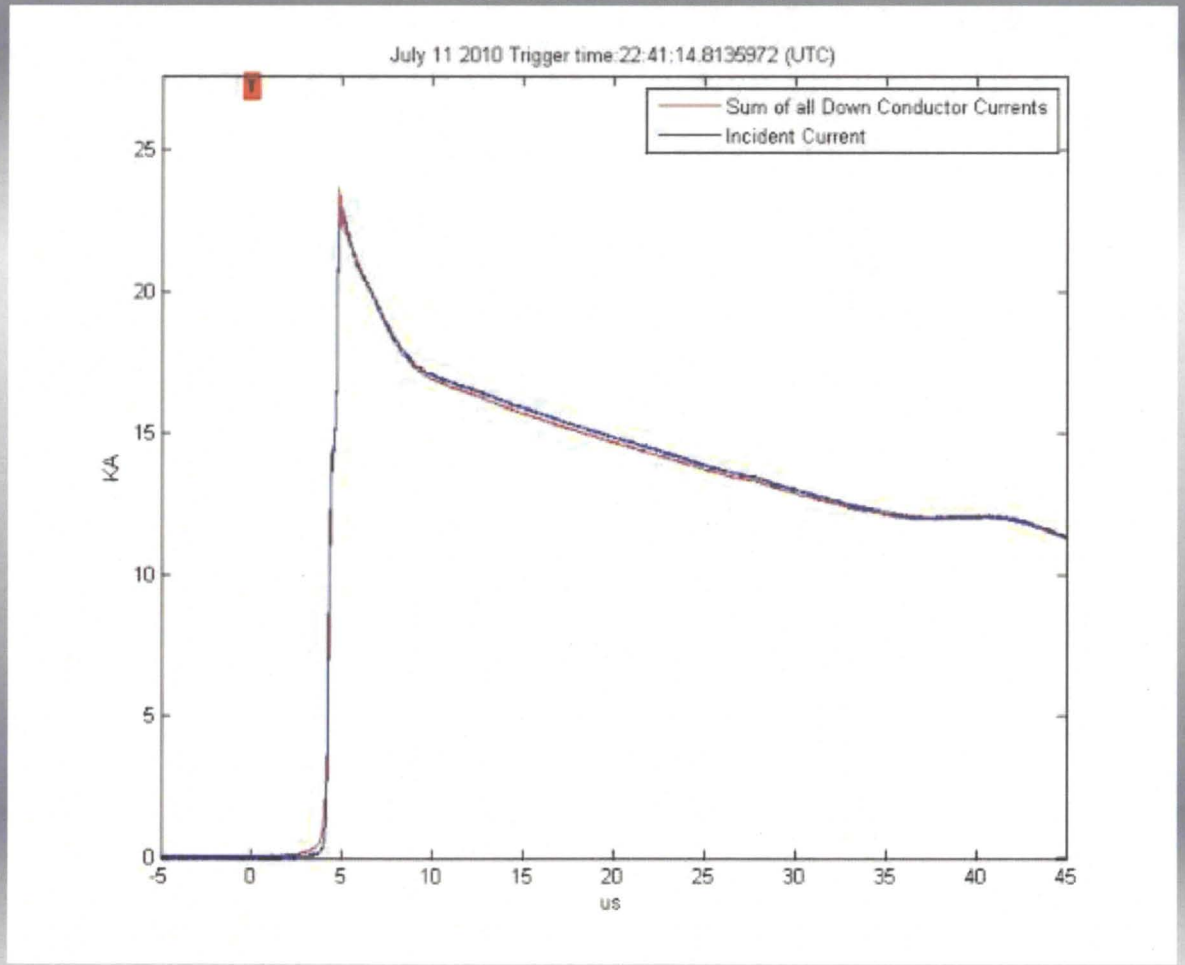
Direct Triggered Lightning Strike

Comparison of incident and sum of all down conductors currents



Down conductors' current distribution. Peak incident current (I) 22.98 KA

DC#	IDCpeak [KA]	% of I
1	3.02	13.16
2	2.18	9.47
3	2.45	10.67
4	2.29	9.98
5	2.17	9.43
6	2.34	10.17
7	2.56	11.15
8	3.87	16.86
9	3.84	16.73

Data Acquired at Camp Blanding

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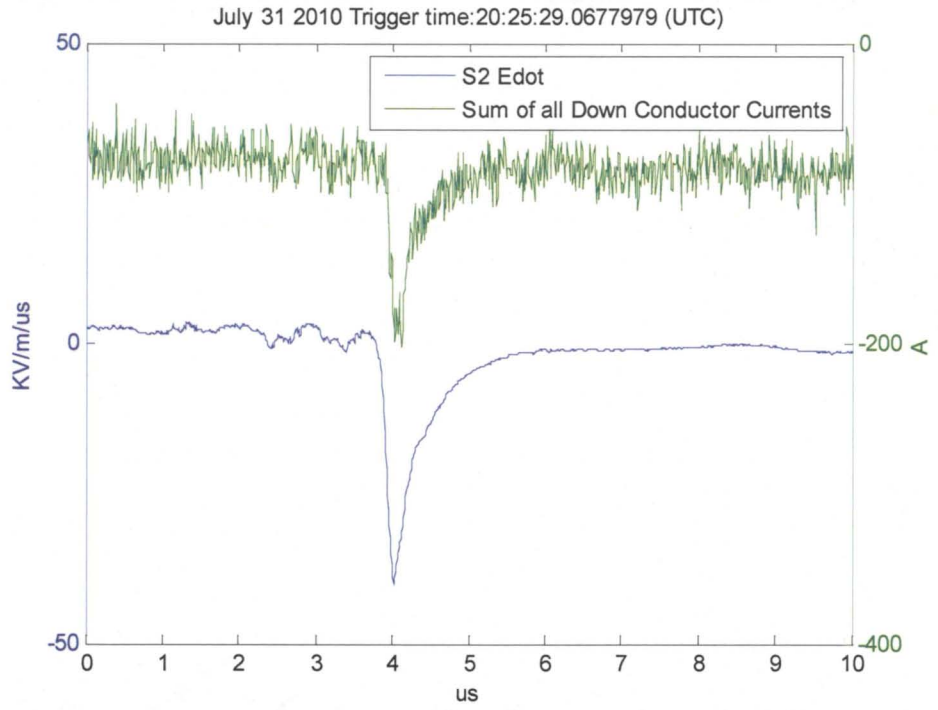
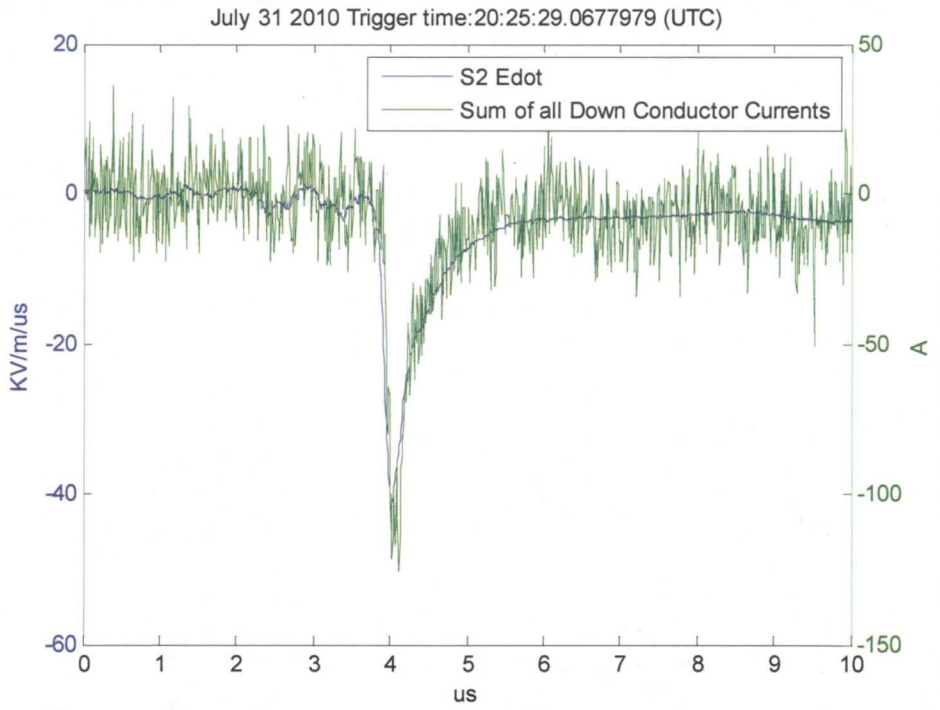
Nearby Triggered Lightning Strike

Comparison of S2 dE/dt (38 meters south of dE/dt measurement underneath the scaled-down LPS) and sum of all down conductors





No DC Offset compensation

DC Offset compensation:
Sum of all Down Conductor Currents = -77.2165 A
S2 dE/dt = 2.1178 KV/m/us

Data Acquired at Camp Blanding

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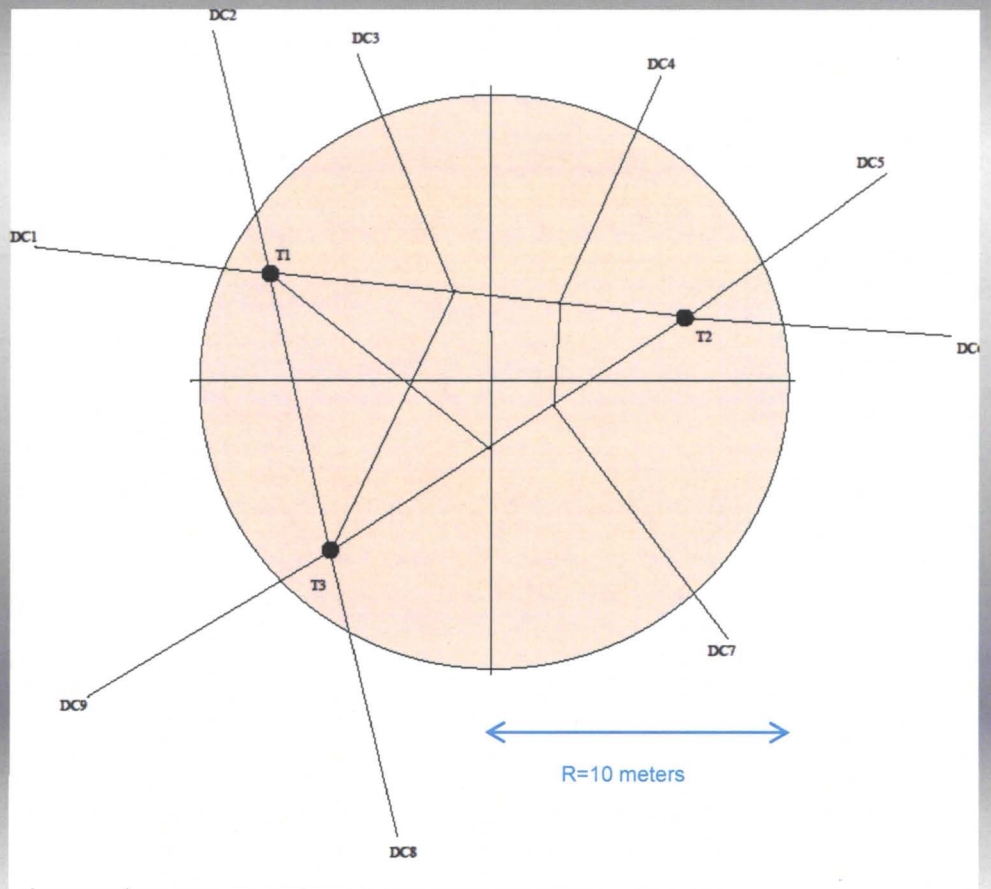
Nearby Triggered Lightning Strike

Displacement current (I_d) and Electric field change dE/dt relation

$$\Phi_E(t) = \mathrm{A}\, E(t); I_d(t) = \varepsilon_0\, d\Phi_E(t)/dt$$

$$\mathrm{A} = \frac{I_d(t)}{\varepsilon_0\, dE(t)/dt}$$

It is worth noting that the dE/dt used for this calculation was acquired 38 meters south of the dE/dt measurement underneath the scaled-down LPS



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Thanks

Questions?